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STRUCTURE OF OPALS

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Résumé - Une exposition de 21 photos, envoyées par J.V. Sanders, a été organisée pendant l'Atelier. Les photos montrent les répliques, vues au microscope à balayage, des surfaces des opales naturelles et synthétiques fraichement clivées. Les répliques mettent en évidence plusieurs structures qui consistent en empilements des billes de silice de diamètres compris entre 1500 et 4000 Å.

Abstract - An exhibition of 21 micrographs, provided by J.V. Sanders, was organized during the Workshop. The photographs show replicas, as seen in a scanning electron microscope, of freshly fractured opales. Several structures, corresponding to packings of silica spheres 1500 to 4000 Å in diameters, are identified.

Opals are known for the display of colours which they exhibit. It has been pointed out /1,2/ that these colours are caused by light diffraction from regular threedimensional structures arising from the regular packing of spherical particles of silica, 1500-4000 Å in diameters.

A series of shadowed replicas of freshly fractured opals was examined by means of a scanning electron microscope. The micrographs are divided in four groups. The first group shows arrangements of spheres of identical size. (Figs 1 and 2) The second group is concerned with "ordered alloy" structures composed of particles of two (or more) sizes. Two different phases /3/ corresponding to compounds AB and AB_{13} are shown in figs 3 and 4. A theory of a best packing available for systems of spheres of two (or more) sizes has been developped in ref /4/. The theoretical results are in agreement with the observed alloy structure.

The third group of photographs shows "exotic" structures in a volcanic opal (Idaho). This material consists in many bands of silica particles, whose size is constant within a band, but varies enormously from band to band (Fig. 5).

The last group (Fig. 6 and 7) is concerned with the structure within the silica spheres formed naturally. There is a strong evidence that the silica spheres were formed by an agglomeration of much smaller particles.

REFERENCES

1 - SANDERS J.V., "Colour of precious opal", Nature, 4964 (1964) 1151
2 - SANDERS J.V., "Diffraction of light by opals", Acta Cryst. A24 (1968) 427
3 - SANDERS J.V., Phil. Mag. A 42 (1980) 705
4 - MURRAY M.J. and SANDERS J.V., Phil. Mag. A 42 (1980) 721

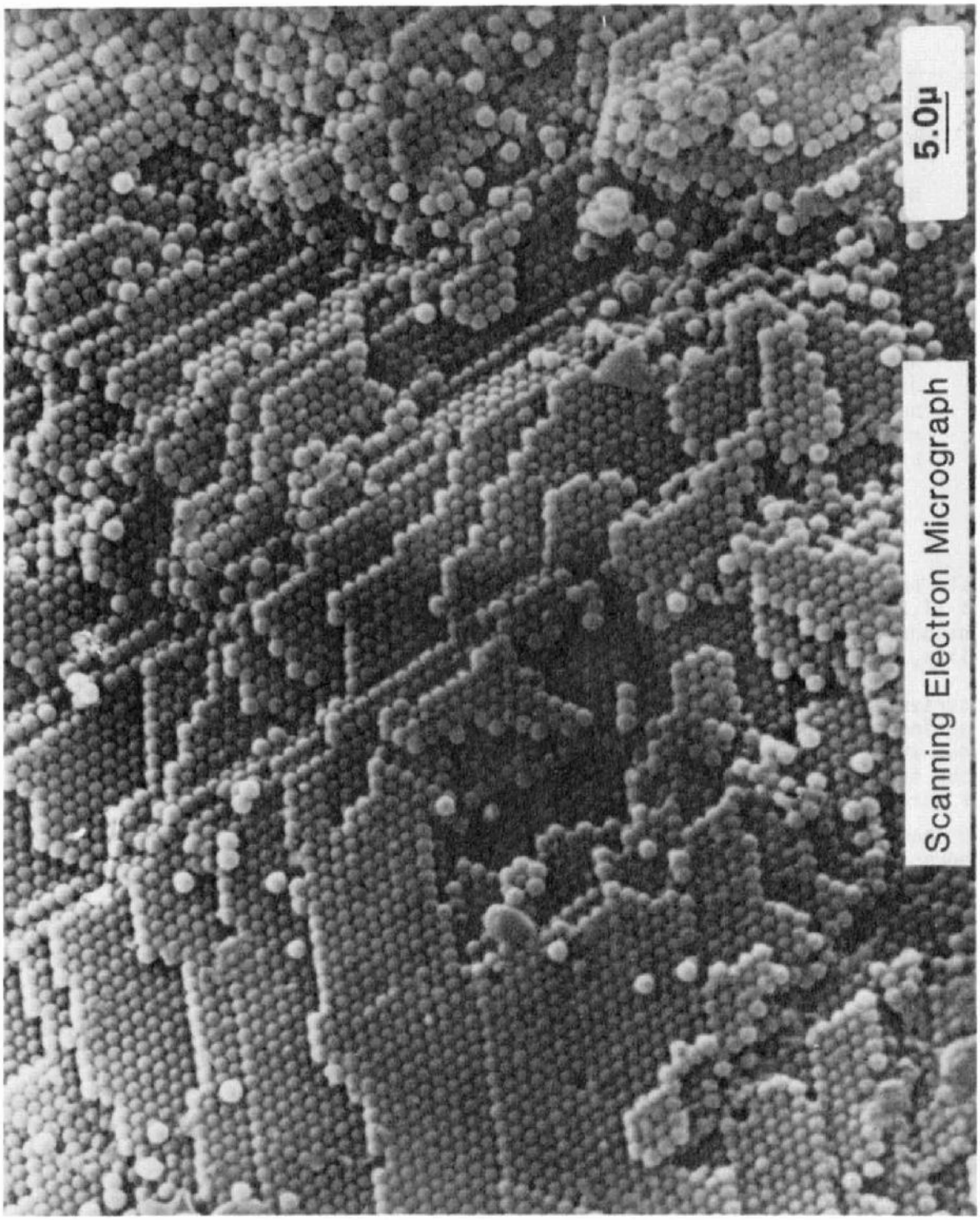

Fig. 1 - Scanning electron micrograph of a smooth surface of a synthetic precious opal made in Australia (L. Cramm).

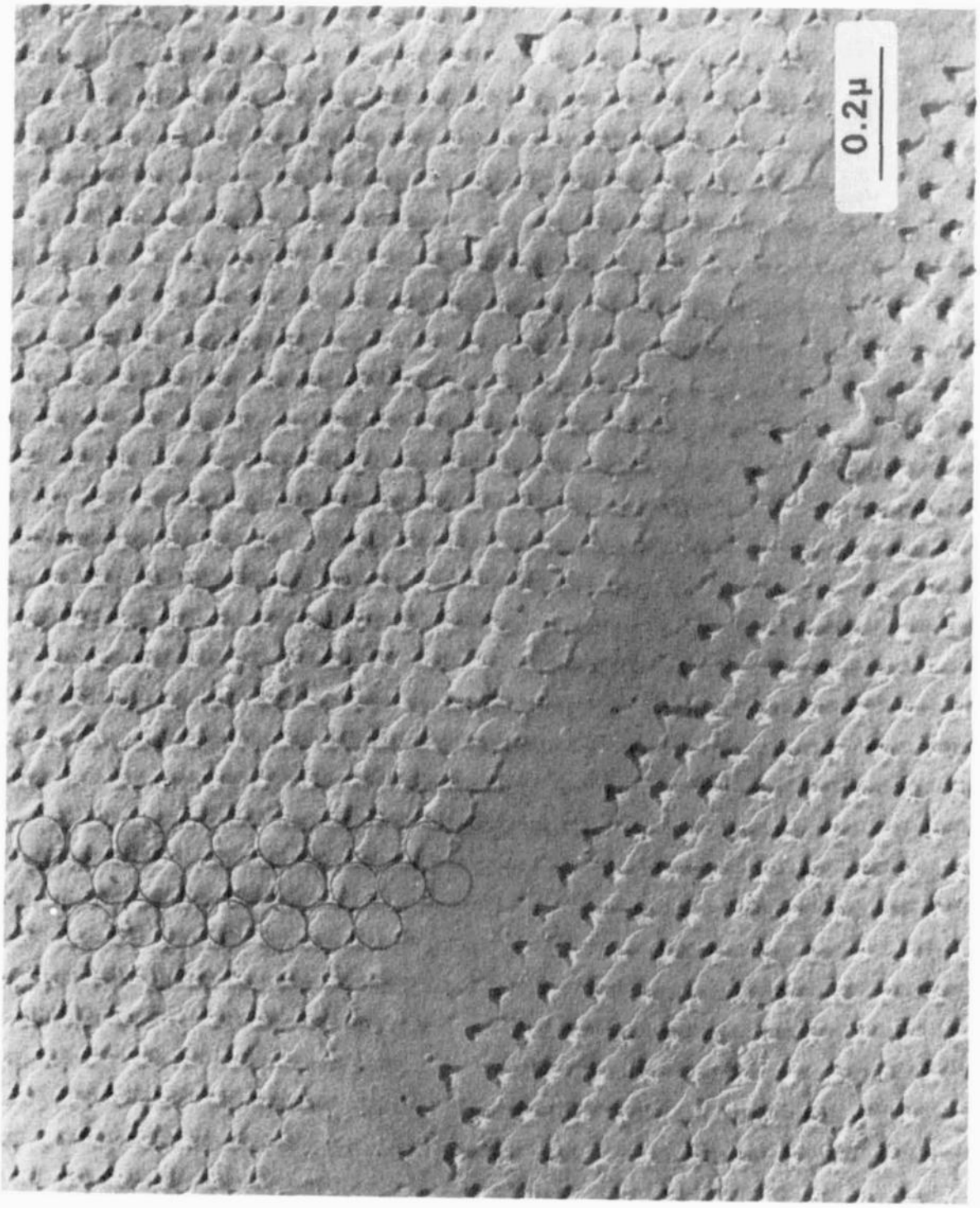

Fig. 2 - Natural opal ; close packing of identical silica spheres

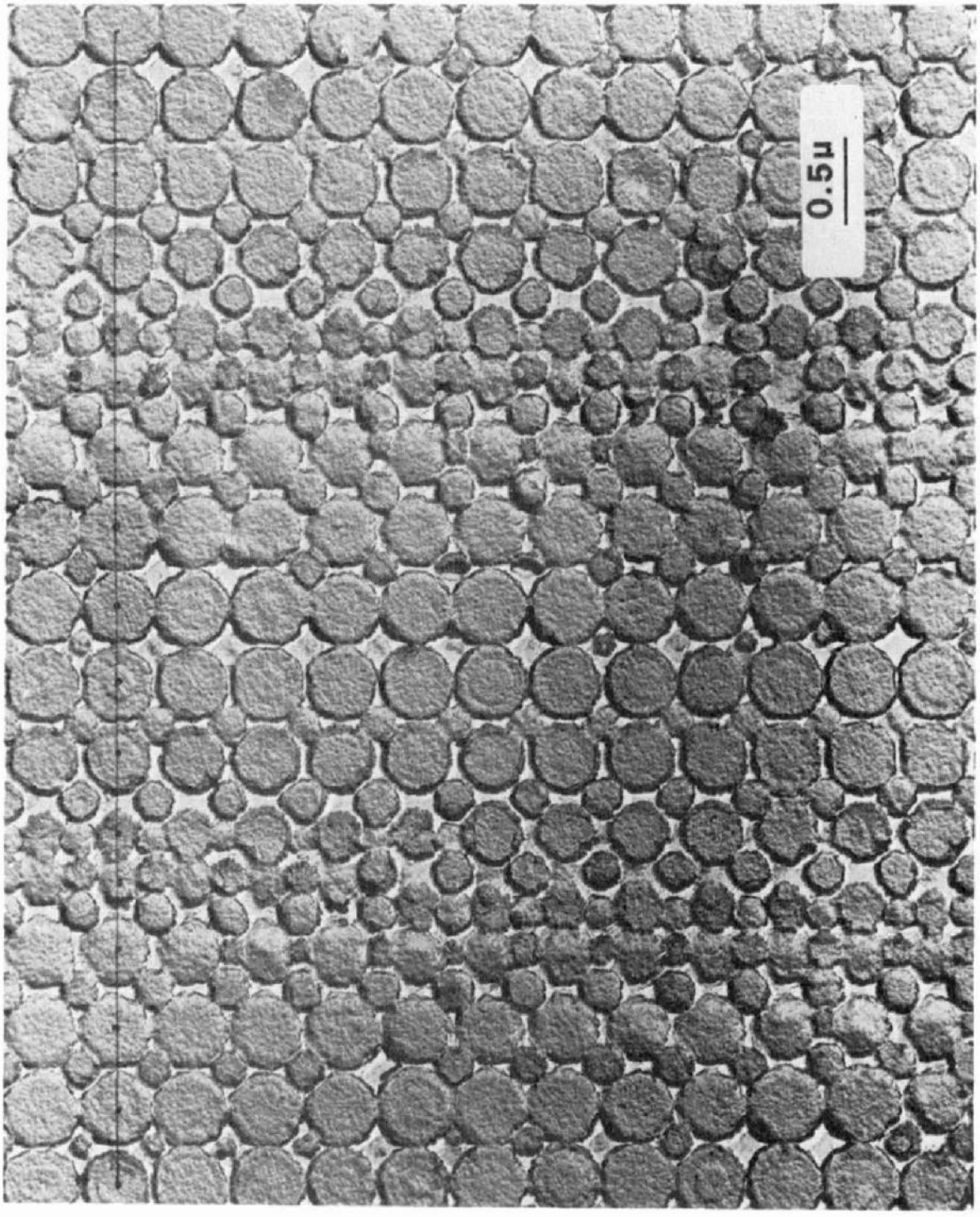

Fig. 3 - Alloy opal : section through layers of alternately large and small spheres in the AB structure.

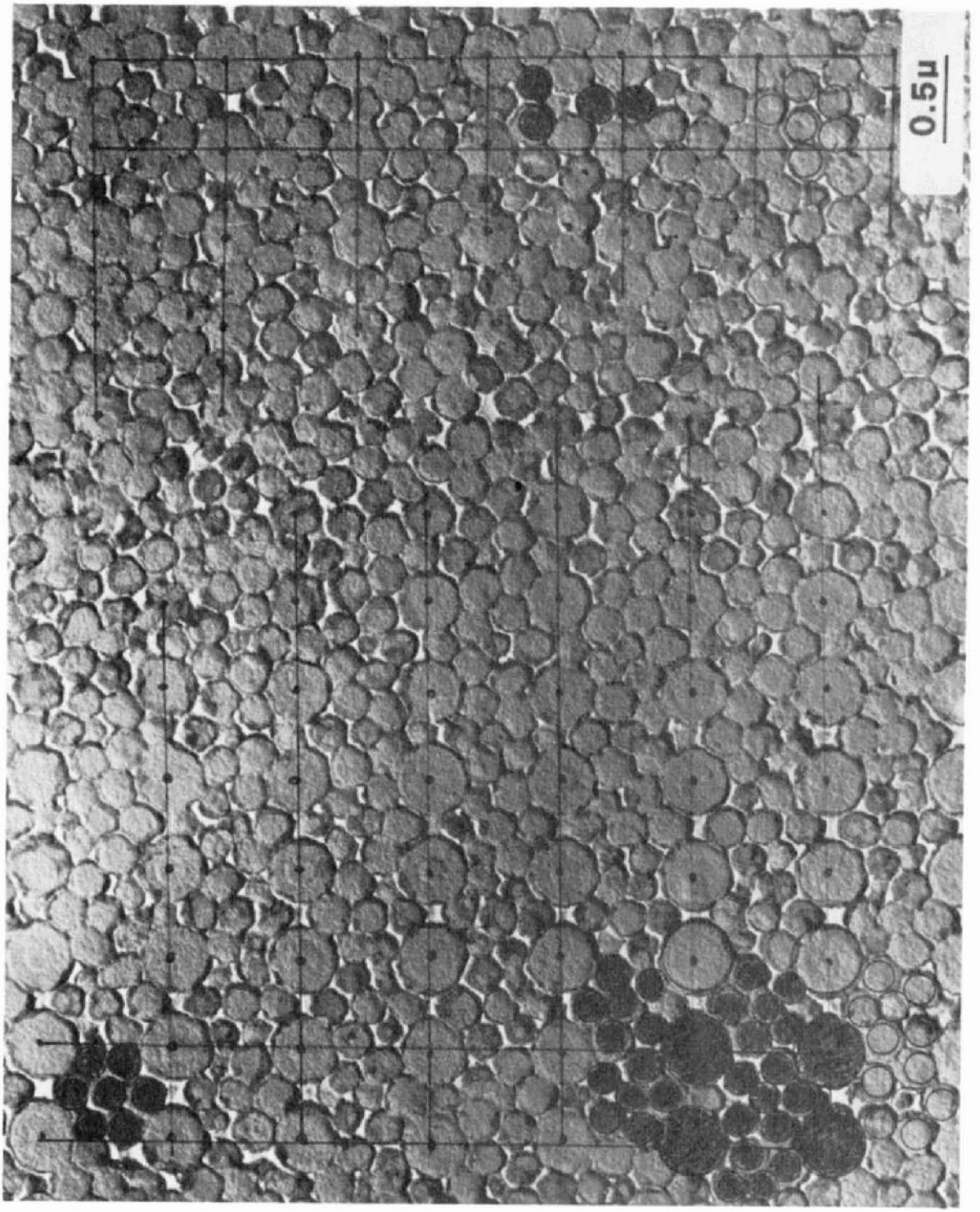

Fig. 4 - Alloy opal : a complex arrangement of the AB_{13} structure

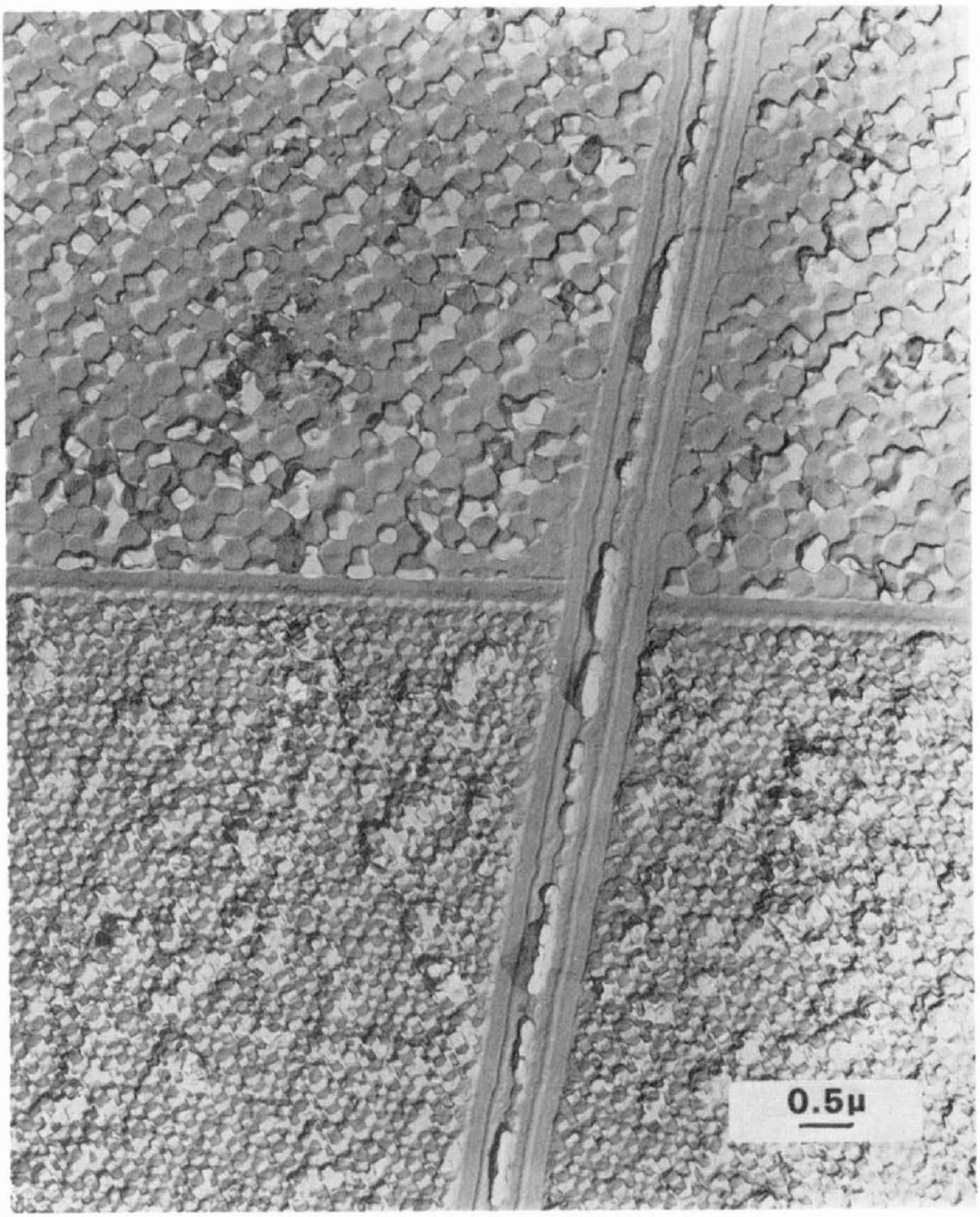

Fig. 5 - Volcanic opal (Idaho). This material consists of many bands of silica particles which size is constant in one band but varies from band to band

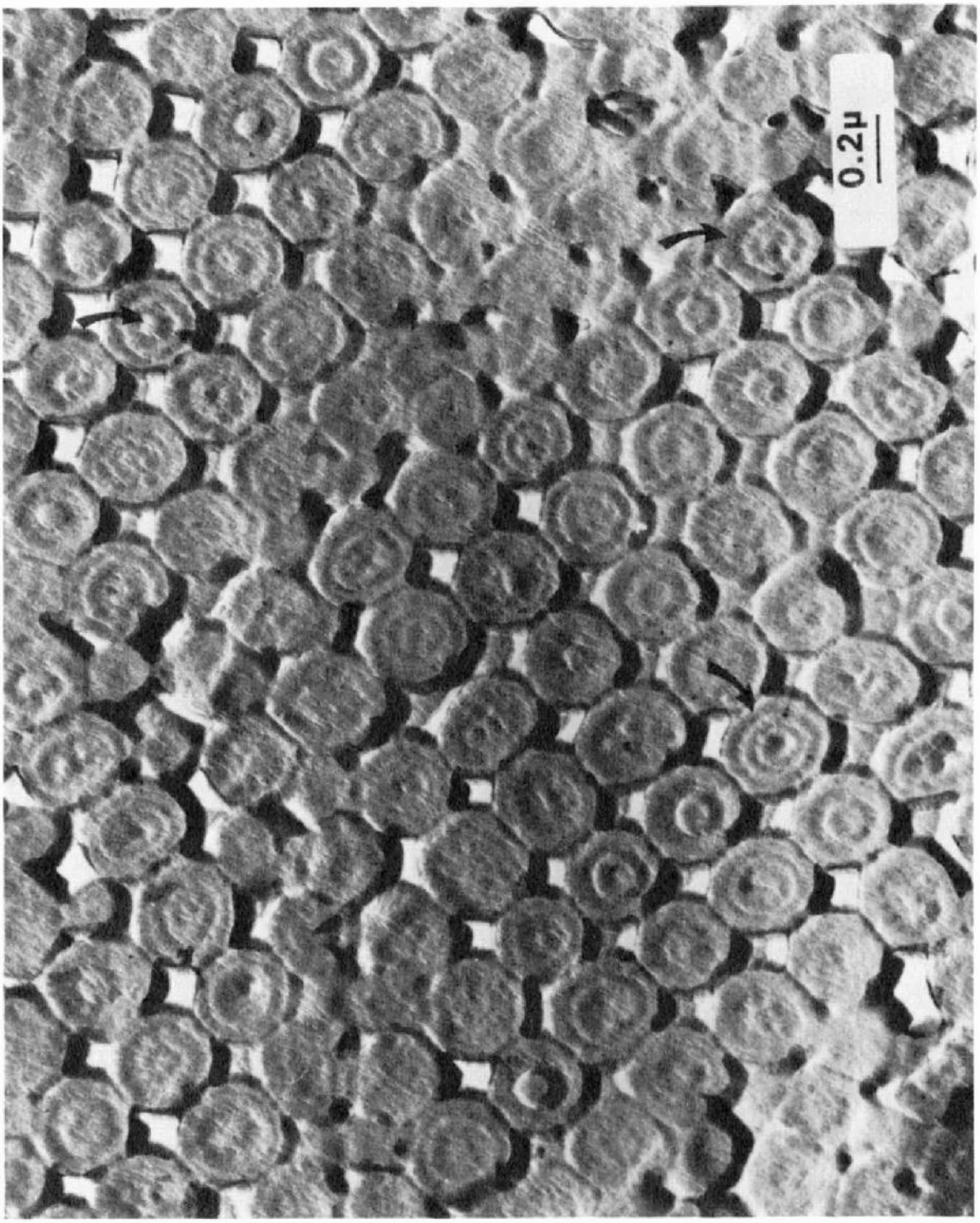

Fig. 6 - Internal structure of SiO_2 spheres : typical set of shells in the precious opal (lightening Ridge). Etching with HF reveals the central nucleus and three concentric layers.

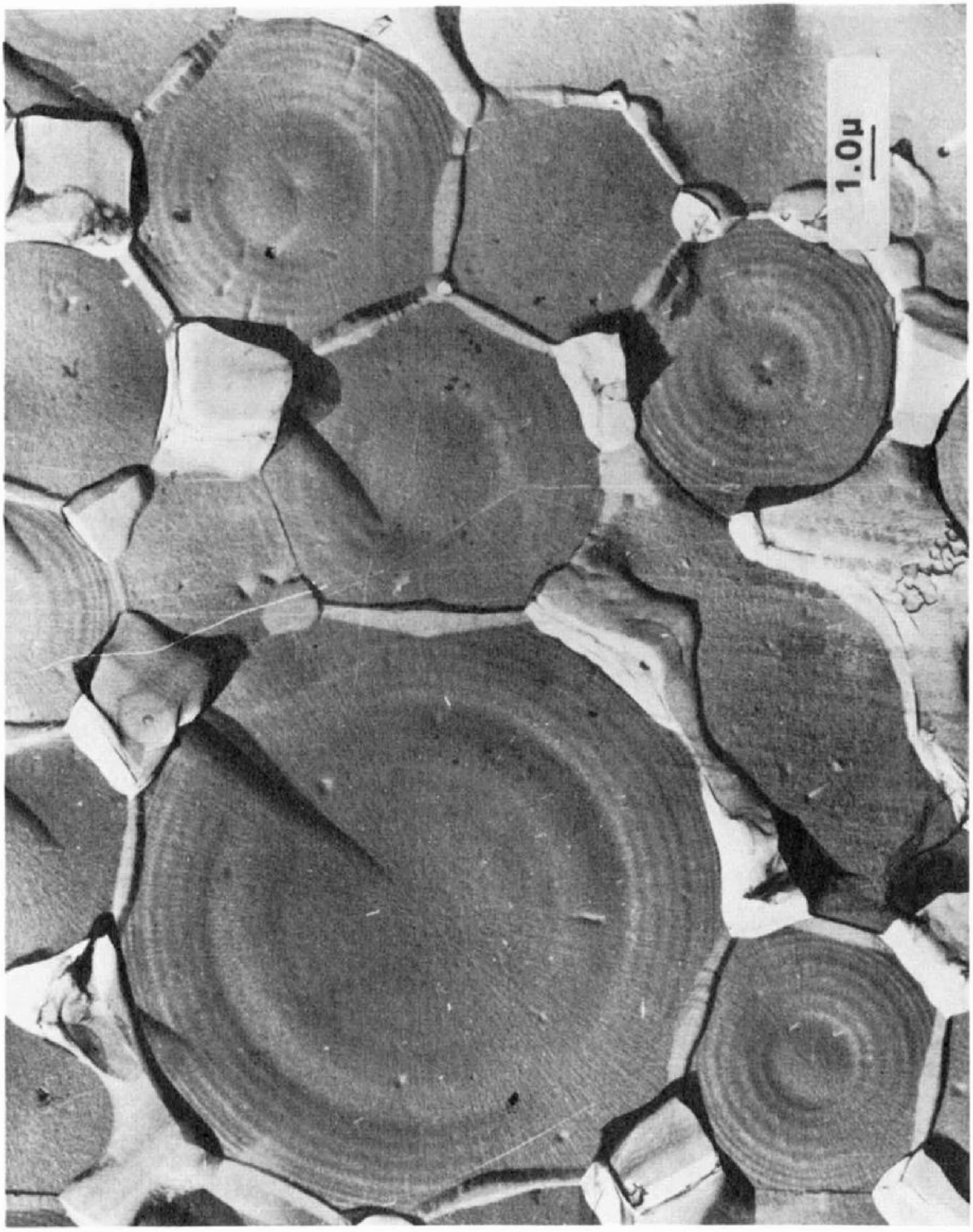

Fig. 7 - There large spheres are also made of shells, whose thickness decreases as $1/r^2$ indicating that the volume of each shell is the same.